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ABSTRACT

The Committee on Science and Technology of the National Academy of Sciences recommends that a Council for Science and Technology be established as a staff agency in the Executive Office of the President. The Council would consist of at least three full-time members drawn from the sciences, engineering, and related fields. They would be appointed by the President, with the counsel and consent of the Senate, to advise the government regarding the best use of science and technology in the development of public policy. Among the areas in which scientific and technological advice was deemed necessary were weapons research, energy resources development, and pollution control. The proposal also includes a brief history of the cooperation and communication which has existed between the government and the scientific community. (MLH)

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SCIENCE AND TECHNOLOGY IN PRESIDENTIAL POLICYMAKING

A Proposal

Report of the
ad hoc Committee on Science and Technology

NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D. C. JUNE 1974

NATIONAL ACADEMY OF SCIENCES

OFFICE OF THE PRESIDENT
2101 CONSTITUTION AVENUE
WASHINGTON, D.C. 20418

June 26, 1974

In the spirit of its charter, to help assure that the United States maintain a vigorous scientific and technological enterprise that is fully utilized in the national interest, the Council of the Academy convened a committee to assess arrangements whereby scientific and technological judgments may best contribute to formulation of policy at the highest levels of the Executive Branch of Government.

The committee was chaired by Dr. James R. Killian, Jr., Honorary Chairman of the Corporation, Massachusetts Institute of Technology, who served as Special Assistant for Science and Technology to President Eisenhower and has rendered distinguished public service in numerous other capacities.

I have the honor to present for your consideration the report of that committee entitled, "Science and Technology in Presidential Policymaking: A Proposal."

The recommendations therein are endorsed by the Council of the National Academy of Sciences which joins with me and with our committee in hoping that these recommendations will receive your early and serious attention.

Respectfully yours,

Philip Handler

Philip Handler
President

The President of the United States
The White House

The President of the Senate
Washington

The Speaker of the House of Representatives
Washington

May 31, 1974

Dr. Philip Handler
President, National Academy of Sciences
Washington, D.C.

Dear Dr. Handler:

In response to an action of the Council of the National Academy of Sciences, you convened this *ad hoc* Committee on Science and Technology last fall "to look into the question of scientific and technical advice to the government, including the advisory and coordinating functions previously carried out by the White House science advisory complex."

The committee has the honor to present herewith its report. It is our hope that after review by the Academy Council the report will be transmitted to the President and to the Congress.

The opinions and the conclusions asserted in this report are those of the committee that undertook to prepare it; in that sense the work is completely our own. But we would be ungrateful if we did not acknowledge our debt to colleagues who prepared papers at our request on special aspects of our deliberations. There were in all thirty such papers or memoranda, some of which are listed by subject and author elsewhere in this report. The substance of those papers, and at times the language, are represented throughout the report.

Colleagues whom we believed to have special knowledge or special insights were invited to participate in one or more of our meetings and thus shared in our deliberations. A number of scientists, including social scientists, were visited individually, and their views have helped shape the report. Others sent us informal communications on problems of science and policy.

Formal acknowledgment is made on subsequent pages; here, at the very outset, we want to express our appreciation of the help we have received.

In addition to the long meetings held by the committee, the Chairman, the Vice Chairmen, and Mr. David Beckler met frequently, serving as a steering committee. The Chairman expresses his indebtedness to Drs. Kenneth Pitzer and Emanuel Piore, the two Vice Chairmen, who shared much of the burden of the

chairmanship. Mr. David Beckler was indispensable in serving the committee as Executive Assistant, and his intellectual contributions to our report were invaluable.

The committee also had the great good fortune to have Mr. Stephen White, Vice President of the Alfred P. Sloan Foundation, join its deliberations, to serve as critic of our findings, and to add substantive content to our report. He patiently and lucidly prepared a series of drafts, enduring without complaint the inevitable revisions that the committee found necessary to clarify and settle its own ideas. In every sense he, like David Beckler, was a working member of the committee and one of the architects of this report.

The committee also welcomed Mr. Robert N. Kreidler, Executive Vice President of the Alfred P. Sloan Foundation, who attended its meetings and added his insights as a social scientist and a former member of the White House science advisory staff.

Finally, the committee expresses its indebtedness to you and to President Robert Seamans of the National Academy of Engineering. We appreciated your wise counsel and the interest you took in our deliberations, as well as your assistance in spurring the committee to bring its findings rapidly to completion and publication.

The committee itself was composed of individuals with highly diversified backgrounds, drawn from engineering, the physical and biomedical sciences, economics and political science, with broad experience in industry and in government advisory mechanisms and organizations at the highest policy levels. That a full consensus was achieved by the members of the group on the conclusions and recommendations in this report is itself noteworthy and reinforces my confidence in the soundness and workability of the measures we propose. I would like to express my deep appreciation for their constructive participation in the work of the committee.

Yours sincerely,

J. R. Killian, Jr.

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A Proposal To Assure the Best Uses of Science and Technology in the Development of Public Policy: *An Outline and Summary of the Committee's Report*

> Science can be effective in the national welfare only as a member of a team, whether the conditions be peace or war. But without scientific progress no amount of achievement in other directions can insure our health, prosperity and security as a nation in the modern world.
>
> VANNEVAR BUSH
> *Science: The Endless Frontier*

I The Committee Concludes That the Office of the President Could Benefit from a Scientific and Technological Presence

The focus of this report is science's service to government. The central question is how to assure the best uses of science and technology in the development of public policy, and the principal objective is to recommend means by which the unique contribution of science and technology can most effectively be incorporated into the policymaking process.

That science and technology are constantly transforming the world is manifest. Indeed, the process is so pervasive that its implications tend to be overlooked or neglected. For several hundred years, the growth of scientific knowledge and the development of new technologies have been changing the character of human life. Today, and for the forseeable future, science and technology will continue to be the chief engine of change in our society.

Science is an intellectual endeavor that has extended the reach of man's mind out to the furthermost galaxies and into the recesses of the atom's nucleus and promises one day to provide an intimate comprehension of man himself. Science and technology are something more than the material goods they provide; they are enterprises of the human mind and spirit as it learns how to make the most out of man's potentialities. And, as twentieth century Americans, we are doubly proud of this human achievement. Nowhere else has the scientific enterprise so flourished and been so productive as in the America of the last few decades.

The impact of science and technology on government steadily grows. Success in addressing many of the nation's most urgent problems must increasingly depend on the wise and benign use of science and technology. If the quality of our society and the aspirations of our people are not to be diminished, it is necessary to bring to bear the most competent and imaginative science and technology that the nation can muster. Even a brief listing of current problems eloquently makes the point: the threat of worldwide famine and the vital importance of continuing agricultural research and of related technological development, in industry as well as government; the need for new technologies to prevent or reverse the deterioration of our environment; the need to find new sources of energy; the need to maintain our defensive strength in achieving a stable, just, and peaceful international order; the acute need for moderating the arms race as the nuclear nations proliferate; the modernization of our transportation systems as an essential part of maintaining a benign environment; the need to advance the science and technology required to provide general access to health care of high quality and to reduce the incidence of disease; the maintenance and improvement of government policies to ensure that American science, technology, and industry continue to flourish. All the nation's profes-

sional resources will be required to cope successfully with these challenges.

In this age, when the uses of science and technology have been so impressive in contributing to the solution of the problems of society and in opening new opportunities for its betterment, we are persuaded that the Office of the President can benefit from some substantial institutional mechanism for dealing with the scientific and technical aspects of major issues that must be resolved at the Presidential level. The view of science and technology that the Presidency requires is that of means by which opportunities can be identified and problems can be met or obviated, in a manner not constricted by the jurisdictional positions and specialized missions of the concerned departments and agencies of government.

We are quite aware that the burden of the Presidency is one of balancing conflicting interests and assessing tradeoffs among alternative courses of action, which almost always carry with them both positive and negative consequences of technological development. No reasonable decision about energy self-sufficiency can be reached, and no choices among alternative technologies can be made without scientific and technical judgments about the costs, feasibility, and environmental consequences of coal gasification, breeder reactors, solar energy, and other possible new sources of energy. No intelligent choice can be made upon desirable automobile emission standards independent of technical judgments about the effects of various pollutants upon health. No conclusions can sensibly be taken about new weapons development without technical judgments about feasibility, cost, and predicted performance in relation to national security objectives.

In few instances will the final choice be solely or even predominantly a matter of scientific and technical judgment; in each case other judgments and values are involved. These values and judgments in public policy arise from society and its institutions, as interpreted and led by elected officials. But many policy judgments must have an important and ineradicable scientific and technical core. The advice called for is not merely the exercise of judgment or choice among well-defined alternatives; rather, the best scientific and technological talent must be intimately involved in identifying and judging new alternatives. These judgments in turn, require, an

understanding of prospective developments at the frontiers of science and technology.

The fundamental thesis of this report is that the process of summation that takes place at the level of the Presidency requires accessibility of scientific, technological, and engineering counsel at that level. There have been and will again be occasions when the assistance is called for by the President himself and should be delivered directly to him. More often, in the daily process, the need is for interaction between the President's scientific counselors and fellow planning or management instruments within the White House. Such interactions are necessary to identify problems and opportunities calling for scientific and technical judgments and to assure that, as policy takes shape, the scientific and technical considerations will be given their appropriate weight and the full range of technical options is presented, from among which policymakers may decide in a fully informed manner.

The committee has reached the conclusion that science and technology can fully serve the federal government—and the nation—only if adequate means are included within the staff structure of the Executive Office of the President to provide a source of scientific and technological analysis and judgment to the President and the agencies in his office.

In arriving at our recommendations, we have considered various alternative arrangements for providing such scientific and technical analysis and judgment to the Office of the President, including those of the past and present. We have considered the adaptation of the Office of Management and Budget so that it could perform the necessary science and technology functions in the Executive Office of the President. With regard to current arrangements, we view with admiration the efforts of the Director of the National Science Foundation in also serving as Science Adviser to the President, but we have concluded that this arrangement is inherently unsatisfactory and insufficient to serve the needs of the Presidency.

These and other arrangements were debated, but in the end we concluded that while some previous arrangements were effective and appropriate for *their* time, there is *now* need for a new arrangement.

The first recommendation of this committee, therefore, and the recommendation from which all the rest follow, is that a Council for Science and Technology be created within the Executive Office

of the President. Other voices have spoken for such a council. We have sought in this report to define the nature of such a council and its functions and to explore the implications of its presence within the Executive Office. This arrangement institutionalizes a critical review capacity for making judgments on the conclusions of scientific and technical experts, recognizing the diversity of scientific and technological knowledge and experience required to address societal problems. It can provide the President, therefore, with balanced judgments deriving from the pooled knowledge and insights of a small group of first-rate scientists and engineers who are full-time members of the Executive Office organization.

Programs spanning the entire spectrum of fundamental research, applied research, development, and utilization of the end products of this process are planned and managed by almost every major department and agency of government. For the nation, it is imperative that the *totality* of the federal program represents a balanced response to society's needs, as perceived by the President and the Congress, and opportunities and directions, as perceived by the technical community. There are few major national goals whose achievement rests on the applied research and development program of a single agency. The applications of research are often unpredictable, depending in large measure on the awareness by applied scientists addressing a practical problem of new research findings, wherever they were obtained. Thus, the pluralistic pattern of broad research and development programs sponsored by many agencies serves the nation in good stead. To be sure, it is national policy that we maintain a healthy, vigorous national fundamental scientific endeavor. That is made evident in the program of the National Science Foundation and in the basic research sponsored by the National Institutes of Health, the Department of Defense, and other departments and agencies.

Hence, it is of enormous importance that there be, within the Office of the President, a knowledgeable body capable of assisting the President in overseeing this vast total endeavor—about $20 billion in FY 1975—to assure its balance, to be aware of unexploited opportunity, to assure that the nation will, tomorrow, have those resources and capabilities necessary to optimize the future contribution of science and technology to the national welfare.

A Council for Science and Technology seems admirably suited to that purpose.

The Congress is increasingly aware of the need to develop its own tools with which to grapple with the same sets of problems, issues, and opportunities. We are gratified that the Office of Technology Assessment is now in being. As the Congress considers its own reorganization, additional instrumentalities to these ends may be created. Under those circumstances, it has appeared to this committee that it can best serve by seeking to shape instruments that will serve the executive branch of the government, endeavoring in so doing to profit from the lessons learned within the structure that has now been largely dismantled—conserving its strengths and avoiding its weaknesses. It is to those ends that this report is devoted.

A brief statement of the committee's seven recommendations and a corollary proposal appear below. Each is subsequently considered at greater length in the body of the report.

II The Committee Proposes a Council for Science and Technology

1. *We recommend that a Council for Science and Technology be established as a staff agency in the Executive Office of the President.*

The council would consist of at least three full-time members, highly qualified by training and experience to serve the needs of the President. Members would be drawn from the sciences, engineering, and related fields. They would be appointed by the President with the advice and consent of the Senate and would serve at the pleasure of the President. One member would be designated by the President to be chairman and would bear the responsibility of reporting to the President. While we have concluded that it would be best to establish the council by legislative action, we recognize that alternative means may be preferable at a given time.

It is essential that members of the council gain the confidence of the President and his Office and that its chairman, possessing this confidence, have access to the President.

Given this confidence and this access, the council can be of great assistance to the President in the difficult decisions he inevitably must make. Wisely and humanely used, technology can serve the highest aspirations of our society. Used in an unenlightened manner, technology can be destructive and wasteful. Our purpose in making this recommendation is to urge that the President have

immediately at hand the means to obtain the best scientific and technical judgment of the nation to aid him in reaching decisions where science and technology are involved.

In our judgment, the council we propose will best accomplish this, but we recognize that a given President may choose some other way more in accord with his style. More important than any specific structural suggestions is the recognition that science and technology at this time of worldwide scarcity and insecurity have a benign and fatefully important role in the making of policy at the Presidential level.

Further discussion of this recommendation will be found beginning on page 19.

2. *We recommend that the Council for Science and Technology be empowered and enabled to draw upon the best talents available in the nation's scientific, technological, and engineering communities both from within and outside the government.*

To be of value, counsel in all these areas must reflect the most advanced current knowledge over the whole range of science, technology, engineering, and medicine. No council, however large, can cover the entire range. To exercise its own functions, the council will be obliged to seek assistance from individual consultants and from panels of specialists. It would draw heavily on departments and agencies themselves, as well as upon the resources of industry, the universities and nonprofit research centers, the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

Further discussion of this recommendation will be found beginning on page 28.

The Committee Proposes Strong Working Relationships between the Council and the Departments, Agencies, and Other Offices of the Executive

3. *We recommend that the Chairman of the Council for Science and Technology serve as a member of the Domestic Council.*

Among the problems and policies with which the Domestic Council, as well as the departments and agencies that are its con-

stituent members, must deal, a substantial number involve components of science and technology not always well perceived within either the Domestic Council or its agencies. The committee believes it to be in the best interests of the work of the Domestic Council in support of the President that the Council for Science and Technology be assigned a strong presence in it.

Further discussion of this recommendation will be found beginning on page 32.

4. *We recommend that the Council for Science and Technology participate actively in the work of the National Security Council.*

The National Security Council must organize its work in a fashion that will best serve the President in accord with his preferred manner of dealing with national security affairs. Consistent with that requirement, there should be provision for systematically introducing into the work of the National Security Council the judgments of qualified scientists and technologists. We trust that the Council we propose would be looked to, as was the President's Science Adviser and the President's Science Advisory Committee, for provision of the nation's best scientific and technical knowledge and judgment, particularly in those matters that involve advanced technology or the insights and early warnings that scientists working at the frontiers of their specialties are qualified to transmit. In this fashion, the National Security Council can benefit from highly professional judgments on military technology and arms control, undistorted by jurisdictional lines of thought.

Further discussion of this recommendation will be found beginning on page 39.

5. *We recommend a role for the Council for Science and Technology in those areas of foreign policy strongly affected by scientific and technological considerations.*

In a speech to the United Nations on April 14, 1974, the Secretary of State said, ". . . In a global economy of physical scarcity, science and technology are becoming our most precious resource. No human activity is less national in character than the field of science. No development effort offers more hope than joint

technical and scientific cooperation." Within this context, Dr. Kissinger directed his remarks toward the needs of the developing countries. Relationships with the developed countries as well are affected deeply by developments in science and technology as they work upon the international scene and America's position on that scene. International relationships in all their aspects are involved in bilateral and multilateral agreements in science and technology. The Council for Science and Technology, working with the National Security Council and the Secretary of State, can help generate and respond to Presidential initiatives to attack mutual problems through international scientific and technological cooperation.

Further discussion of this recommendation will be found beginning on page 43.

6. *We recommend that the Council for Science and Technology cooperate closely with the Office of Management and Budget on significant budget and management issues involving science and technology.*

The Office of Management and Budget must possess a strong scientific and technological competence of its own, but such inhouse competence cannot completely meet the needs for the full range of expert counsel required. The council we recommend should serve as a scientific and technical resource to the Office of Management and Budget and should assist in the allocation of resources for the government's scientific and technological programs. We believe that the council could be of great assistance in participating with the Office of Management and Budget in evaluating the quality and technical feasibility of major proposed programs and in placing them in some order of priority.

Further discussion of this recommendation will be found beginning on page 46.

The Committee Proposes Annual Reports on Matters of Importance to National Policy

7. *We recommend that the Council for Science and Technology submit an annual report to the President, and through him to the*

Congress, on major developments in science and technology of significance for national policy.

These annual reports to the President are not to deal with the overall state of science and technology, but with specific major developments and trends within science and technology that offer significant new opportunities or raise important problems. For the Congress and for the public-at-large, the most important service the report can provide will be to illuminate opportunities and problems that affect society as a whole.

Further discussion of this recommendation will be found beginning on page 49.

The Committee Offers a Corollary Suggestion Concerning Long-Range Policy Research and Analysis

In considering the needs of the federal government for scientific and technological counsel, the committee has been especially struck by the lack of capability for long-range policy research and analysis, which would examine continuously the longer run implications of current budget decisions and other policies and would seek to anticipate problems that will face the President and the Congress in future years. These functions involve careful and imaginative integration of the analytical methods of science, engineering, economics, statistics, public administration, and other social sciences. At present, the federal government, in general, and the Executive Office, in particular, are inadequately equipped to avail themselves of powerful methods that scholarship has developed for policy research of long horizon and wide scope.

Recommendation of a specific organizational design for policy research and analysis is beyond the scope of this committee. We do emphasize the essential importance of this function, however, and while the proposed Council for Science and Technology cannot itself perform this function, we suggest that the usefulness and effectiveness of the council would be greatly increased were there available a mechanism for systematic long-range policy research and analysis.

We propose, therefore, that consideration be given to means by which the Executive Office of the President could benefit from im-

proved and still developing techniques of policy research and analysis. As scientists, we are aware of the close relationship of these new techniques to the method and spirit of the physical, biological, and behavioral sciences, and we believe that a way can be found for making them continuously useful to the Executive Office of the President.

Discussion of this proposal will be found beginning on page 34 and in appropriate portions of the report.

CHAPTER ONE

BACKGROUND

Earlier Experience

This report deals with the organization of means for providing a scientific and technological contribution to the determination and execution of policy within the executive branch of government. It rests upon the conviction that individuals expert in science and technology in most instances may and in some instances must be called upon (1) to help define issues that call for formulation of policy, (2) to assist in the process that will determine those policies, and (3) to contribute to the programs and operations that are brought into being to exercise those policies.

It has been recognized that to ensure the wise and benign use of science and technology and to formulate policies to achieve those objectives, the President needs to possess in some continuing form the capacity to call upon the scientific and technological community, and a variety of institutional forms have been created or adapted to that purpose. For more than a century, the government has been able to call upon the National Academy of Sciences for advice and assistance from the nation's foremost scientists. With the First World War, awareness mounted that science and technology could be called upon in times of crisis.

Between the two world wars, there were inconsequential attempts by government to employ the advisory services of scientists and technologists, but it was not until the outbreak of war in Europe in 1939 that a useful coalition between science and the government began to take form, in a fashion that explicitly stressed services for the war effort. Upon the direct initiative of scientists and engineers, a National Defense Research Committee was established in 1940 under Dr. Vannevar Bush. A year later the committee became one of the two major arms of the Office of Scientific Research and Development, which for the first time brought an instrument of scientific and technical counsel and research within the Executive Office of the President, in the Office for Emergency Management. The accomplishments of the Office of Scientific Research and Development were decisive, and the comments made about that organization by Don K. Price, some years after it had been dissolved in 1947, are instructive:

> As head of an independent agency in the OEM, Vannevar Bush had every right to go directly to the President on issues involving the use of science and scientists during World War II. A position of direct responsibility to the President was not important mainly in order to let Dr. Bush as head of OSRD have personal conversations with President Roosevelt. It was much more important to give him the leverage he needed in dealing with the vast network of administrative relationships on which the success of a Government agency depends. This is the point that is completely missed by those who think that the ideal position for a scientific agency in Government is one of complete separation from the political executive.
>
> It was this position of direct responsibility to the President, combined with his own personal qualities, that enabled Dr. Bush to deal with military leaders on equal or better than equal terms, in order to push the development of specific weapons in which leading generals were not interested. This position also let him exercise over Government policies a vigorous influence that had an important effect on the use of scientists. For example, radar would never have played its timely part in World War II if Dr. Bush had not been able to exercise enough influence with the Selective Service System to protect the younger electronic experts against the operations of the draft. Nor could the whole structure of contractual relations have been maintained had he not been able to persuade the General Accounting Office to relax many of its normal peacetime rules with respect to accounting and contracts.[1]

[1] Don K. Price, *Government and Science*, New York: New York University Press (1954), p. 45.

The years following the termination of the Office of Scientific Research and Development saw spectacular progress in organization for federal support of science and technology. However, the scientific advisory function at the Presidential level was more or less dormant until the pressures of the Korean conflict again brought forward the need.

The manifest need for scientific and technological counsel persuaded President Truman, in mid-1951, to request a study of the problem. In a remarkably prescient study, William Golden recommended that the President establish a Science Advisory Committee and appoint a Presidential science adviser. The recommendations were accepted by President Truman, but, during the short period of his administration that remained, no strong links were forged between the President and the Science Advisory Committee, established in the Office of Defense Mobilization, and it was little used. Under the administration that followed, however, the committee grew rapidly in status and function, as described by Dr. Lee A. DuBridge, who served as its chairman from 1952 to 1956:

> With the warm support of President Eisenhower as he came into office, our activities were stepped up, special studies were initiated by ad hoc panels and many reports and recommendations were made to the President on broad problems of national security. The President requested certain of these reports to be presented to the National Security Council. . . . Two panel studies directed by James R. Killian, Jr., and H. R. Gaither, Jr., respectively, were especially important and influential.[2]

The Science Advisory Committee had thus evolved into the first scientific body to be located within the Executive Office with a charge that went beyond *ad hoc* purposes.

Another crisis in 1957 dictated still another change. *Sputnik* sent a shock through the body politic, and President Eisenhower perceived an immediate need to relieve what he called "the current wave of hysteria" and to accelerate missile and satellite programs. He turned both to Dr. Detlev Bronk, President of the National Academy of Sciences, and to the Science Advisory Committee, then

[2] Lee A. DuBridge, "Policy and the Scientists," *Foreign Affairs, 41,* 579 (April 1963).

chaired by Dr. I. Rabi. As the President himself later reported, the committee pointed up the need for a Presidential science adviser.

> Dr. Rabi had another suggestion. Many policy matters coming to the President, he said, include a strong scientific component. He therefore recommended the appointment of an outstanding, full-time scientific adviser to the White House staff. This I thought a fine idea and remarked that an adviser in that position would also be helpful in stimulating interest in science.[3]

President Eisenhower acted at once. Three weeks after the meeting with the Office of Defense Mobilization committee, he addressed the nation over radio and television and announced the creation of the position of Special Assistant to the President for Science and Technology, to be filled by Dr. James R. Killian, Jr. It was around that post that a full science advisory mechanism within the White House and the Executive Office took shape. The Science Advisory Committee of the Office of Defense Mobilization was transferred to the White House and renamed the President's Science Advisory Committee (PSAC). The committee was empowered to name its own chairman; in practice throughout its lifetime that chairman was the Special Assistant. In 1959, there was created the Federal Council for Science and Technology, on which were represented the departments and executive agencies with scientific and technological activities; in 1962 the staff to the Special Assistant and PSAC was organized within an Office of Science and Technology. The entire apparatus functioned within the White House and the Executive Office. It represented for the first time fully funded, fully staffed scientific advice close to the President and those immediately surrounding the President.

The mechanism continued until early in 1973, when President Nixon sent to Congress a Reorganization Plan that effectively abolished the entire mechanism. The White House post of Science Adviser was terminated, the resignations of the members of PSAC were accepted, the civilian functions of the Office of Science and Technology were transferred to the Director of the National Science Foundation and the security functions to the National Security Council. At the present time, no body with broad responsibility for scientific, technological, and engineering advice exists in the White House and the Executive Office.

[3] Dwight D. Eisenhower, *The White House Years: Waging Peace, 1956–61*, Garden City, New York: Doubleday, pp. 204–225 (1965).

Lessons Learned

Although the brief historical account we have given here is useful to a full comprehension of where we now stand, our purpose in this report is to look forward rather than backward. While undoubtedly there are political lessons to be learned from the past, our concern is with the future and with the provision of effective scientific and technological inputs to the decision-making process.

In formulating its recommendations, this committee has sought to benefit from the lessons learned during the years of the President's Science Advisers, PSAC, and OST and to propose a new structure that will reflect those lessons. The recommendations are designed

- To emphasize counsel grounded in science and technology, answering to the needs of government;
- To provide, so far as structure alone can do so, a mechanism for scientific and technical inputs as an integral part of the decision-making process of the Executive Office of the President;
- To make explicit the relationship between the science and technology advisory mechanism and other arms of the White House and the Executive Office, namely coequal partnership in the staff processes, useful to the extent that it contributes to that process;
- To extend the services of the mechanism more deeply into civil problems while restoring those of national security;
- To recognize two functions that need improvement in the Executive Office of the President in relation to that of providing independent scientific and technical counsel, *viz.*, the study of policy options in a planning context and upgraded analytical and technical capability for dealing with day-to-day decisions in the Executive Office; and
- To assure the fullest relationship with Congress compatible with the location of the mechanism within the Executive Office.

Much of what we have recommended is structural, but the committee is aware, of course, that structure alone cannot assure an ultimate solution. A structure that brings counsel, supported by analysis, close to hand and that delivers its findings efficiently and smoothly can be of vital importance. The committee has sought to describe such a structure.

The details of what the committee has proposed and the arguments that support the recommendations in this report will be found in the pages that follow.

CHAPTER TWO

THE PROPOSAL

A Council for Science and Technology

1. *We recommend that a Council for Science and Technology be established as a staff agency in the Executive Office of the President.*

In making this recommendation, we contemplate a council, preferably established by legislative action, consisting of at least three full-time members, accomplished in the sciences, engineering, and related fields. They would be appointed by the President with the advice and consent of the Senate, and serve at the pleasure of the President. One member of the council, designated by the President to be its chairman, would bear the responsibility of reporting to the President and would be in charge of the council's staff. This staff should be relatively small, possibly twenty-five or thirty professional members.

The work of the council would be addressed to scientific and technological matters of concern to the President or to agencies in the White House and the Executive Office of the President, which (1) underlie policy or program considerations brought to the attention of the council, or (2) underlie policy or program considerations that may be discerned by the council itself, or (3) may even-

tuate in the medium or long term in issues that require policy determination.

Appropriations would be made annually to the council sufficient to provide it with adequate staff and facilities, to enable it to call upon qualified individuals from the scientific and engineering community for *ad hoc* services, and to enable it upon occasion to contract with organizations outside the government for services related to its functions. In its operations, the council would have the authority to obtain pertinent information from government agencies and to create internal units dealing with civilian technology, natural resources, national security, science policy, and other areas.

As this manner of organization clearly implies, the committee lays great weight upon the establishment of the council within the inner domain of the President. Outside that domain lie the departments, the specialized agencies, the operational entities. It is within the White House and the Executive Office that the balance is struck among the conflicting demands made upon the Executive. The resources to be allocated among them are estimated and the allocations duly made, the conflicts between differing claims resolved, and the entire undertaking weighed in the light of national needs and national well-being.

We of the committee recognize—indeed, the history of scientific and technical counsel at the Presidential level forces us to recognize —that at the level of the Presidency the need is for the generalist rather than the specialist; that specialized advice in any enterprise flows into the top level from departments designed and operated for specific tasks and that the role of the policymaker is to integrate the flow of advice. By definition, the argument runs, specialized counseling is narrow, and what is required at the highest level is a breadth of knowledge and a breadth of vision that can appraise the specialized advice, assign its proper weight in the total enterprise, and render judgments that have taken into account the contributions of every variety of specialist.

We cannot quarrel with that point of view, but it is fundamentally misleading to look upon science, technology, and engineering as *only* specialized enterprises. Each is intimately and inevitably involved, in this world of the twentieth century, with the processes of birth and death, the maintenance of health, the provision of food, shelter, and clothing, the preservation of peace and the waging of war, the

creation and provision of those material resources that supplement our muscles and extend our minds. One set of technologies, largely born of science and made real by engineering, surrounds most of us at our work; another set ministers to our leisure; for most of us a third set carries us between the two; and still a fourth set establishes the general environment (for better or worse) in which all this takes place. Few activities within the entire range of human activities are more general and pervasive.

To be sure, the individual scientist or engineer is likely to possess highly specialized knowledge. But that specificity of individual accomplishment and purpose does not affect the generality of the undertaking as a whole. Indeed, in science and technology, as in few other enterprises, it brings that generality into being.

This truth concerning the scientific and technological enterprise also applies to scientific and technical counsel. In its detail, that counsel is highly specialized, and rests upon the work of highly specialized individuals. At the enterprise level, scientific and technical counsel possesses exactly the kind of generality that is required at the highest levels of policymaking: general in the sense that it is likely to be consequential in almost every function of government.

In fields other than science, technology, and engineering, this duality has been recognized. The professional economist, like the professional scientist, is likely to be a man whose own achievements in his professional field are the consequence of intense specialization. But it has been acknowledged that economics, like natural science or technology or engineering, is in a broader sense a method of dealing with experience; as an enterprise the experience with which it deals is coextensive with an enormously broad range of human endeavor, and in a most important sense relevant to that endeavor. That recognition has most appropriately brought the Council of Economic Advisers into the Presidential environment, as well as the economic competence embodied in the Office of Management and Budget. Similarly, the lawyer, whose professional competence at the highest level may be quite specialized, has been recognized over the years to be in a broader sense a member of a profession with an analytical approach to a broad range of human endeavor, and his counsel is welcome for that reason.

The lawyer has been given that recognition for centuries, the economist for decades, the engineer upon occasion. To make simi-

lar claims for the scientist and the technologist is perhaps more recent and may appear more surprising. But this report does make that claim, and we believe it to be fully warranted. Of course, whatever the specialist's field, his capacity to advise the makers of high policies depends not only on his experience and training but also, most crucially, on his personal qualities of intelligence, wisdom, judgment, humanity, and perspective.

The generality of the scientific, technological, and engineering enterprises suggests the qualifications for membership on the Council for Science and Technology. By the very nature of the task they are to undertake, they should be persons of accomplishment in the physical, biological, or behavioral sciences, or in technology, or in engineering.

Since their task is to provide counsel with respect to major societal matters that entail a strong scientific or technological component rather than counsel with respect to a specific technical problem, the counselors must be drawn from that subset of accomplished scientists or technologists or engineers who, having had broad experience in administrative and political tasks within their own professions, can bring an analytical approach to management problems. This is not a small group, as one can readily see in observing the number of scientists and engineers in top policy and management positions in many of our corporate and educational institutions.

The intellectual strength that such persons bring to government is not only the special knowledge of the research scientist or engineer. However eminent the scientific counselor may be or may have been in the field of his own special research, only infrequently will he be called upon for counsel directly related to that research. Rather, the demand made upon him at this level is that he be able to comprehend and evaluate the state of science and the direction of science (or technology, or engineering) over a broad front. His strength and usefulness must derive from a deep familiarity with the fundamentals of science and engineering, with science and technology as an enterprise, and with the manner in which it operates.

For the council to function effectively, it must have the confidence of the President, the Presidential staff, and the scientific community. The structure suggested here, with members of the council and its chairman selected by the President, is intended to promote a direct relationship between the President and the council, especially its chairman.

The scientific, technological, and engineering communities are likely to judge nominees for the council and its chairmanship on the basis of the confidence and professional respect that these communities repose in them. That confidence and respect is profoundly necessary. Equally important, however, is the nature of the relationship that nominees may be able to engender with the President and among the President's direct staff.

The most effective relationship between a President and a close adviser is personal in the deepest sense; something more than confidence and respect is then involved. Legislation can only provide institutional arrangements that facilitate and encourage such access. Beyond that, there is little that can usefully be recommended.

We have stated our preference that the council be established by legislation, that the Senate concur in the selection of the council members, and that funds be appropriated directly for its support. Such a procedure endows the council with stability and with continuity.

This, then, is the committee's primary recommendation, from which most of the remaining recommendations flow. We believe that the structure we propose is sound, that it is workable, and that it is and will continue to be needed. But we also recognize that it deals with one of several staff mechanisms available to assist the President and that its value will depend on how well it contributes to the total decision-making process.

Nature of Council Activity

The council is intended to be a staff body contributing to better information and understanding in the Executive Office decision-making process. It is coordinate with and should act in concert with the Office of Management and Budget, the National Security Council, the Domestic Council, the Council of Economic Advisers, the Council on International Economic Policy, and other agencies in the Executive Office of the President. This committee does not propose operating responsibilities for the Council for Science and Technology. The council is not intended to carry out scientific research, whether pure or applied, and the development effort that is generally the necessary next step after applied research. All have homes elsewhere in the government apparatus—in the various departments

and agencies, in the National Science Foundation and National Institutes of Health, and in the private sector.

At the highest level of government, outside the operating agencies themselves, there must be oversight of those activities that involve review, management, allocation of resources, and assignment of responsibilities, particularly for programs that cut across two or more agencies. Most societal problems cannot be resolved by science and technology alone, but their solution or management almost always entail significant scientific and technological content.

Prior to formulation of programs, however, are the broader questions of policy, out of which the operations themselves may be said to emerge. The formulation of policy over the entire range of government operations may profit from scientific and technological counsel—indeed, may find it essential. This has occurred in a variety of ways.

One relates to the anticipation of problems and opportunities. The scientist or the technologist working at the very frontier of new knowledge construes it as his first responsibility to extend that knowledge in the one instance, or to apply it in some new form to human needs in the other. To that extent, as C. P. Snow has phrased it, he has "the future in his bones"; some unique insight into the shape the future might take and the problems as well as the benefits that the new science or the new technology may bring in its wake. Thus Enrico Fermi, on learning the news of nuclear fission, set about at once to conduct experiments that would extend knowledge of the phenomenon and, at the same time, was able to warn the United States Navy that, one day, the deployment of its power might have to take cognizance of nuclear weapons.

There are abundant areas of scientific and technological enterprise today in which this kind of forecasting and early warning may be vital to the orderly evolution of social and political arrangements. The engineer, with a professional knowledge of the movement of industrial processes and industrial complexes, can envisage a host of problems lying before society in the fields of communications, energy production, environmental pollution, and land use. Biological scientists, rapidly gaining insight into living nature, can envisage use of that basic research for development of medical technologies that may challenge some of humanity's basic verities, as well as for food production.

The lead time of a major technological development may be in the order of ten years. There is the additional lead time to gather the scientific knowledge that oftimes makes existing technology economically viable, or creates entirely new technology. The subsequent social, industrial, and political consequences of that technology may be profound and proceed at their own pace. Ideally, the new social and political arrangements should evolve hand in hand with the science and technology, in a fashion that enables them to come to fruition at the same moment. That ideal can never be achieved, even in principle, let alone in practice, but there is at least some hope that if scientific and technological forces in being are brought to the attention of those who must make social and political policy, the gap will be narrowed and the transition eased.

But even under the best of circumstances, the early warning will at times fail and the problem will become a crisis. For example, political and economic forces triggered the acute aspect of the energy crisis. In such instances, scientific and technological counsel takes another form: It directs itself toward mobilization of the scientific and technological resources that can respond to the crisis.

There have been instances in which science and technology have themselves resolved the crisis: The creation of a synthetic rubber industry during World War II is perhaps the best such example. More often than not, as in the recent energy crisis, the resolution in the short term must come from political action (in the instance of the energy crisis, the complex series of steps that led to the lifting of the oil embargo) and from social action (conservation measures of various kinds). But such crises almost always have as a consequence the *ad hoc* mobilization of science and technology and analysis to assure that the crisis does not recur, perhaps in more virulent form, or that the threat of recurrence does not constrain the nation's political or social freedom of action.

Scientific and technological counsel can help assure that the response to a national need possesses a sound technological and scientific base. In the absence of sound counsel, the steps that will be taken may not prevent a recurrence of the crisis or restore the nation's freedom of action. In the face of an energy crisis, it is not self-evident to what extent the recourse should be to increased exploitation of coal, or the development of solar power, or agreement on design standards for nuclear power plants. Only scientific and

technological counsel, procured from those who have intimate and deep knowledge of the technical elements involved and interpreted by those with broad technical experience, can then provide to decision makers at the highest level any sense of assurance that the solutions adopted will in fact have the desired consequences, the availability, safety, and environmental results that are so dearly desired.

These two forms in which science and technology may serve the policymaker are likely to arise in all the areas within which policy is defined. It is clear they arise in such areas as energy resources; the production of energy is itself a task for technology and engineering. It may be less clear that they arise, though sometimes with equal force, in areas in which neither science nor technology is necessarily recognized to play a part. There is, for example, as we shall take note in a later section, a significant science and technology component in foreign affairs policy.

It is our view that there do not at present exist governmental instrumentalities that might readily be adapted to the functions that we propose for the Council for Science and Technology. The most obvious candidate is the Director of the National Science Foundation, and indeed he has been charged by the Reorganization Plan with some of the functions of the former White House science and technology advisory apparatus.

The Director of the Foundation now wears two hats, one as the President's Science Adviser and the other as director of a line agency that is concerned primarily with the health and vitality of basic science and education in the sciences and with the support of applied scientific research relevant to national problems. Both the Director and the National Science Board have the responsibility "to recommend and encourage the pursuit of national policies for the promotion of basic research and education in the sciences." As head of an operating agency, he must deal for the most part with considerations that should not enter the high level deliberations concerning the scientific and technological activities of other agencies and departments that, in some sense, are in competition for resources and pride of place with the National Science Foundation itself. These comments do not constitute a negative reflection on the Director of the Foundation himself or on his leadership; rather, they express a conviction that the Director of the Foundation should not be placed in a conflict-of-interest situation that calls upon him to per-

form duties that are basically inconsistent with his responsibilities for accomplishing the mission of the National Science Foundation.

We have recommended a council of "at least three" members. By this we mean to suggest that we have no strong feelings about the exact number but that we favor neither a large council nor a single adviser.

Our principal objection to a large council, numbering perhaps a dozen or more members, derives from the fact that large numbers diminish the role played by any single member and that it would consequently be most difficult to attract scientists and technologists of the necessary stature and competence from their customary activities. Yet we feel it to be most essential that members of the council, however many they may be, devote themselves full time to the council. We believe that the nature of the work demands that kind of commitment and also that the members of the council be clear of any implications of conflict of interest.

It can be argued that the range of science and technology is so great that it can be fairly represented only by a large council. We do not, however, see the council as representative in that sense, as the next section of this report will make clear. The full range of competence that is required will be drawn from the best-qualified members of the communities of science and technology as a whole and need not be fully embodied in the council itself.

We believe that the council will best be served if its chairman and members become accustomed to working as a council, joining together into a single endeavor with a common purpose, as a team. The larger the council membership, the more likely it is that the task will be divided and that teamwork will give way to some kind of functional organization.

Finally, we believe that the council with the kind of membership we recommend will avoid efforts to overcentralize the nation's scientific endeavor, as Warren Weaver wrote in his essay, "A Great Age for Science."

> We should avoid like the plague
> the enticing danger of too much,
> and too concentrated, planning
> of our national scientific develop-

> ment. The great majority of scientists agree that the supposed benefits of centralized planning are an illusion [for science]. . . . But we must nevertheless devise some more effective mechanism for overall comparative judgments about national priorities.[4]

The Need for Outside Expertise

2. *We recommend that the Council for Science and Technology be empowered and enabled to draw upon the best talents available in the nation's scientific, technological, and engineering communities both from within and outside the government.*

We have recommended a structure by means of which broad scientific and technological counsel may be provided to the Executive Office on a continuing basis as that office undertakes its task of formulating and analyzing issues.

But in the process of providing that counsel, the counselors themselves will necessarily be aware that resolution of a matter at issue may be dependent upon progress in one area or another of scientific research and development. For example, not only the latest word on the most recent developments but some insight into the developments most likely soon to follow in some such field as magnetohydrodynamics may determine the most advantageous policy to be adopted in the area of energy resources. These facts and insights can come only from active scientists and technologists thoroughly immersed in that field, who know in detail what science and advance technology are up to and—what may be even more important—have deep insights into the directions in which science and technology are traveling yet at the same time are able to judge these developments in broad perspective.

At that level of specialized scientific and technological advice, it is apparent that the association with the government neither can be

[4] Warren Weaver, "A Great Age for Science," *Goals for Americans*, New York: Prentice Hall, Inc., p. 124 (1960).

nor should be a continuing relationship (except for research scientists and engineers in government laboratories). Such highly specialized advice, in practice, is required by the government only at limited times and under limited circumstances. Removed from constant encounter with their research, moreover, scientists quickly lose the ability to provide the highly specialized advice for which they have been sought out, for the value of that advice is dependent upon intimate acquaintance with that research.

Thus the arrangements by means of which the scientific and technological contributions will be made to the formulation of policy must be in two forms. (1) There must be a means of bringing a small number of scientists and technologists into a continuing full-time association with the government, within a structure that permits their counsel to be heard and evaluated. Only a continuing association will enable them to become fully aware of the needs of the government in which scientific and technological assistance is required. (2) There must also be a means of bringing into association with the government, on an *ad hoc* basis, those specialists whose particular competences are needed to deal with particular programs.

Advisory services of this sort have been made available to the government with considerable effect over the past few decades, particularly with respect to national security affairs, in which this advisory pattern was initially adopted on a sizable scale. Specialists have come from many professional backgrounds, from government, industry, universities, and nonprofit organizations, and other areas.

Since World War II, individual agencies of the federal government have developed strong scientific and technical resources of their own, staffed by many accomplished scientists and engineers. Along with drawing upon the outside community, the council should draw upon this inside resource, recruiting for its panels scientists and engineers from a variety of agencies and departments. It should also utilize interdepartmental task groups.

In the years immediately following the close of World War II, a series of advisory studies, under such exotic names as Project Lamplight, Project Charles, and Project Hartwell, laid the base for such significant military developments as defense early warning systems. The Technological Capabilities Panel, under the aegis of the Science

Advisory Committee of the Office of Defense Mobilization (ODM), defined in 1954 the parameters upon which the development of weapons systems to minimize the threat of surprise attack could be reasonably based; a subsequent ODM study completed for the National Security Council in 1957, *Deterrence and Survival in the Nuclear Age*, dealt both with the protection of the civilian population against nuclear attack and with broad defense considerations.

It was in part this history of solid contributions that led President Eisenhower, stimulated by the shock of *Sputnik*, to move, as we have recounted, the ODM Science Advisory Committee into the White House and to establish the post of Special Assistant to the President for Science and Technology. In the next few years, working largely through its advisory panel system, the new science and technology mechanism took the steps that led to the establishment of the National Aeronautics and Space Administration, major improvements in the long-range ballistic missile program, acceleration of ballistic missile early warning capabilities, and major advances in technical capabilities for antisubmarine warfare.

In its larger terms, the relationship between an advisory mechanism and the agencies of the government dealing with national security will be considered in connection with a subsequent recommendation.

Along with the contributions of outside scientific and technical advisers in national security affairs, there have been many instances in areas of domestic concern in which such part-time experts have rendered valuable assistance to the Office of the President, and, through their published reports, to public understanding of how science and technology can contribute to such areas as the quality of the environment, innovation in education, the excellence of biomedical research, the world food problem, the development of alternative energy sources, and the post-*Apollo* space program.

The history of those advisory services, particularly those conducted under the President's Science Advisory Committee, reveals the surprising, seemingly paradoxical, fact that it was the defense agencies that appeared to benefit most from outside advice and counsel, although they possessed the largest scientific and technological capabilities.

This fact underscores the importance of a strong scientific and

technical capability at technical program management and policy levels in the departments and agencies and within the Executive Office of the President, with ability to identify key issues on which to seek outside scientific and technical advice, and to gather such advice and couple it with the decision-making process.

The committee is recommending an advisory system that would bring the experience of scientists, technologists, and engineers into association, however limited, with the formulation and determination of policy at the highest levels of government. Scientists and engineers who participate in the advisory mechanisms have a responsibility to recognize the special requirements and constraints that go with sharing in the policymaking process.

In addition to the use of individual scientific and technical advisers directly by the departments and agencies, the federal government has, since World War II, increasingly called upon the National Academy of Sciences, and more recently its affiliates, the National Academy of Engineering and the Institute of Medicine, for advisory activities. The Academies' study projects and reports have related to almost every aspect of American life. In 1974, the activities of the National Research Council, the operating arm of the Academies of Sciences and Engineering and the Institute of Medicine, are being conducted by 560 committees on which almost 9,000 natural and social scientists, engineers, technologists, physicians, and other specialists serve without compensation.

In recent times an increasing fraction of Academy activities has flowed from requests legislated by the Congress: studies of the effects of herbicides in Vietnam; of the feasibility of control of automotive emissions on the part of the automobile industry; of improvement in the scientific basis for decision making by the Environmental Protection Agency; of the training of physicians, among others. The capabilities of the Academies and the Institute of Medicine to mobilize scientific and technical expertise and to conduct independent studies of high quality should prove to be a uniquely valuable resource to the proposed Council for Science and Technology.

Relationship to the Domestic Council

3. *We recommend that the chairman of the Council for Science and Technology serve as a member of the Domestic Council.*

The Domestic Council was established by a Presidential Reorganization Plan in 1970 to assess national policy needs, develop forecasts to help define national goals and objectives, identify alternative ways of achieving objectives, and recommend "consistent, integrated sets of policy choices." Chaired by the President, its members include the Secretaries of those departments operating primarily in domestic affairs: Agriculture, Interior, Labor, Commerce, Transportation, Housing and Urban Development, Health, Education, and Welfare, Treasury, and Justice, together with the Chairman of the Council of Economic Advisers and the Director of the OMB.

Among the policies and programs with which the federal departments and agencies must deal, a substantial number include components of science and technology. Many programs involve several departments and agencies, and their management is rendered all the more difficult by the mission-orientation that each participant brings to the common task. For example, almost every agency experiences problems that arose out of the shortfall in energy supply; out of concern for the preservation of the environment; out of the newly created capacity provided by the computer to organize and process information; out of the increasingly voracious demands that the growing world population and growing expectations make upon the supply of food; out of fears of scarcity that characterize so many nonrenewable mineral resources.

A number of major issues, identified and analyzed by persons who were invited to contribute statements to the committee, are noted in the acknowledgments accompanying this report. Repeatedly, these statements point to the need for a central overview in the Executive Office of the President of the scientific and technical components of federal domestic policies and programs, while also emphasizing the essential interdependence of science, technology, and fiscal, economic, social, political, and institutional factors in developing policy alternatives.

To cite only a few selected tasks relevant to this report, with which the Domestic Council might well be concerned; we may note the following:

- Development of a transportation research and development policy within the framework of an overall transportation policy.
- Provision of an adequate knowledge base applicable to regulatory decision making within the government in such fields as health, environment, and transportation.
- Development of a research and development policy designed to increase agricultural productivity within a sound framework of land use and environmental quality and considerations of plant and animal genetics.
- Definition of federal policies and programs that can influence long-term growth patterns in the United States in beneficial ways.
- Improvement in the use of technology and resource allocation in relation to health care delivery and the achievement of a balanced approach to research intended to eliminate or mitigate major diseases, drawing on the resources of the National Institutes of Health and other organizations concerned with biology.
- Use of technology to broaden and deepen educational experiences while helping to control cost.

It is, therefore, to assure the wisest use of available science and technology in these and innumerable other aspects of our national life that we recommend that the Chairman of the Council for Science and Technology be a member of the Domestic Council.

Such a coupling between the Domestic Council and the Council for Science and Technology could significantly contribute to the formulation of policy alternatives. But the coupling must go even further. Efforts undertaken in common with the Domestic Council should be viewed as one stage in a process that must extend to the separate departments and agencies themselves.

One aspect of that broader coupling should be a conjuncture of the new council with the already established Federal Council for Science and Technology, of which all federal departments and agencies concerned with science and technology are members. In fact, the establishment of the Federal Council was stimulated by the President's Science Advisory Committee in the late 1950's, as was the appointment of Assistant Secretaries for Science and Technology in various federal departments concerned with domestic matters. The Federal Council deals with common operational matters relevant to technical missions of departments in general and, selectively,

with the formation and coordination of technical programs and policies that cut across individual missions. Membership on the council is representative of the departments at the level of assistant secretary and of independent agencies at the director or deputy director level.

It is our belief that each department and agency with substantial scientific or technical concerns should have an Assistant Secretary or equivalent person charged with responsibility for science and technology within the agency and that it should be one of the functions of the Council for Science and Technology to assist the agencies in procuring for such posts persons of accomplishment from the related communities. Membership on the Federal Council, and active participation in its work, should be assigned those Assistant Secretaries, as is now the pattern.

We believe also that a member of the Council for Science and Technology should sit as a member of the Federal Council for Science and Technology (preferably renamed to avoid confusion with the proposed council). Indeed, given the full breadth of association of the work of the Council for Science and Technology with the aggregate of work of the Federal Council, we think it appropriate that the representative from the Council for Science and Technology be designated chairman of the Federal Council, providing for that body an overview of its endeavors that might otherwise be lacking.

A Capability for Policy Research and Analysis

Because the Domestic Council does not have a well-developed policy research arm, we see a need for a new capability in the Executive Office of the President for long-range policy research and analysis.

In recent years improved methods of policy research and analysis have been introduced, employing some of the methods of the natural and the social sciences together with sophisticated mathematics, some of the technology that mathematics has helped develop, and modern econometrics. Policy research and analysis are devoted to exploring the whole range of consequences, intended and unintended, of policy alternatives, to establishing the nature of tradeoffs

that exist among a variety of policies encompassing a variety of subjects, to the maximization of the benefits that might be achieved, and to measuring the consequences of various modes of government intervention intended to serve the various policies.

This new kind of enterprise has been put in place in some of the departments and agencies and also is characteristic of a number of independent institutions outside of government. It is broadly used by the federal government in both military and civilian applications.

But nowhere is it used to serve the civil ends of government as a whole, exactly as the Council for Science and Technology that we propose is designed to serve the government. Only within the National Security Council is the potential of policy research and analysis systematically exploited; elsewhere it is to be found at the level of the mission departments and agencies. Its value at that level should not be discounted, but neither should its potential at higher levels be ignored.

This committee believes that consideration should be given to the application of long-range policy research and analysis, in some organized fashion, within the Executive Office of the President. We have no informed opinion as to which is the best method for embodying that analytic capability within the Executive Office. However, it could begin as a joint staff organized under the guidance of an internal White House and Executive Office steering group, which would comprise the heads of the appropriate White House and Executive Office agencies, including the chairman of the proposed Council for Science and Technology.

We are aware that a proposal of this sort extends beyond our terms of reference. But we do not believe it to be as distinct a matter as it might at first appear. The presence of such a capability within the Executive Office could render more effective the analyses and assessments that the Council for Science and Technology can provide by subjecting them to further analysis in a structure in which the special insights of economics, statistics, public administration, and other social sciences can play their appropriate part. We believe that if such a capacity is brought into existence, it will in time become indispensable to many of those who advise the President, including the Council for Science and Technology. We believe further that the Council for Science and Technology will be equally indispensable to the policy research and analysis function.

Civilian Technology Policy

It is appropriate that some consideration be given here to government policies for the encouragement of technological development and innovation in sectors other than those in which the federal government itself has a recognized responsibility for the programming of research and development. This includes the bulk of private sector industry, as well as public sector activities such as education and the provision of urban public services, in which there is very limited central programming activity at the federal level. It excludes areas such as the national security sector and much of atomic energy, space, and biomedical research (except pharmaceuticals) where there is a relatively comprehensive federal responsibility. Between these two general spheres of activity, there is a large middle ground where government and private interests are mixed, as in housing and transportation, and where federal policies and programs influence and supplement research and development undertaken by the sector.

Thus, the bulk of decision making regarding the day-by-day allocation of resources for the production and delivery of goods and services takes place outside the detailed purview of any agency of the federal government; the bulk of the immediately related research and development is neither financed nor subject to evaluative review by a federal agency. But it is exactly these individual decisions and activities, taking place in large degree outside the government structure, and certain supporting activities that take place in institutions of higher learning, that determine the technological well-being of the nation as a whole. Certainly, the state of a nation's technology determines to a very significant degree its long-term economic health. The ability of industry and services to generate new technology and technological innovation affects in a substantial way the growth of output per man-hour and, thus, the gross national product and the national standard of living. This is not that other substantial factors are absent, only that technical health is itself an important factor.

The process of instituting technological change is not self-governing. The dynamics and institutional structure of a sector, such as health care, may inhibit the very research and development that, from a national standpoint, would appear to be most necessary. In some instances, institutional relationships, such as in the railroad

transportation industry, discourage research and development and innovation. Exploring the more radical alternatives in one sector or another may be so high in cost as to be beyond the means or incentives of any single enterprise, as in the building industry. Or the new departure may be so potentially perturbing to the sector that there is resistance to undertaking such exploration. Both those effects are felt within the transportation industry.

Although, in general, decisions on research and development in civilian technology are made by individual industrial firms that finance such research and development out of their own funds, federal policy does impinge on these decisions. General tax laws and monetary policies, patent and antitrust laws and policies, export policies, and regulation and standard setting may indirectly encourage certain kinds of civilian research and development and discourage or preclude others.

Some foreign governments have for some time addressed the civilian technology problem, by intervening directly in industrial research and development through subsidies, loans, tax policy, or contracts. But that very process can produce acute problems: perturbation by the government of the existing balance among industries within the same general sector; or displacement of privately financed efforts due to direct governmental intervention in technologies closely associated with product development, thus sacrificing the virtues of pluralistic enterprise.

There have been attempts within the U.S. government to come to grips with the general problem. These have included a civilian industrial technology study by the Office of Science and Technology in the early 1960's, a variety of reports by the Commerce Technology Advisory Board, in particular the Department of Commerce (Charpie) Report on Technological Innovation,[5] a Presidential commission on the U.S. patent system, and the New Technology Opportunities program of the Domestic Council in 1971. None of these, however, dealt with the entire problem; none, even in its own terms, had more than a very limited effect on government policy.

The requirements for framing effective federal civilian technology policies are manifest. First, there must be sensitive appreciation of what matters can be expected to take care of themselves without de-

[5] U.S. Department of Commerce, *Technological Innovation: Its Environment and Management*, Washington, D.C.: Government Printing Office (1967).

tailed federal overview. In industries where there are a number of technologically sophisticated companies and the value of the products is reasonably well reflected in what people are willing to pay for them, there is little reason to believe that private research and development on new products and processes warrant supplementing by public funds or programs. The areas where active public programs might seem justified are those where private markets do not adequately reflect social value, or where the underlying private industry is weak technologically, or where technological research and experimentation of very long range or basic character holds considerable promise of major new possibilities. These are fundamentally different criteria and call for somewhat different kinds of policies.

Second, there must be an organizational capability for recognizing what is going on in each affected sector, covering the existing technology, the technological options, and the research and development being done under both governmental and nongovernmental sponsorship. There must be well-defined criteria, certainly involving sophisticated economic analysis and forecast, against which the prevailing situation can be judged and targets identified for new policy or existing policies abandoned. Finally, there must be means for influencing and supplementing existing activities in each sector, and across sectors, to the extent appropriate and desirable. Those organizational imperatives make it apparent that the task is not one for the technologist alone. The economic aspects of the problem are at once apparent. It can be regarded, in fact, as much an economic as a technological problem.

The federal government must be enabled to define the role it might appropriately play in helping create a favorable climate for stimulating civilian technology, and it must seek the counsel of private industry in doing so. It is the view of this committee that the national interest, private and public, will be served by a national civilian technology policy framework to guide federal actions. A Council for Science and Technology can assist in the development of such a policy framework by providing a continuing overview of the technological enterprise.

Relationship to the National Security Council

4. *We recommend that the Council for Science and Technology participate actively in the work of the National Security Council.*

There can be little quarrel with the position that the national security requires a sustained scientific, technological, and engineering effort if the United States is to maintain strategic sufficiency, to provide effective tactical forces, to mount acute intelligence systems, to promote arms control, and to ensure that, now and in the future, the President will not lack the options necessary to protect the security of the country.

The national security problems faced by the President, containing substantial technical content, are in part program problems and in part policy problems. Program problems include, among other matters, research and development of the major weapons systems and their production and management; the state of underlying military technology; utilization of academic and industrial science and technology and consequently the maintenance of sustained vigor in those enterprises. Policies include those related to the purposes of military forces; military strategy; war gaming; vulnerabilities; essential resources; and the interaction of military and technicomilitary factors with diplomatic, economic, political, and social factors in the equation of national security, specifically including arms limitation and control.

So far as programs are concerned, primary responsibility is firmly lodged within the Department of Defense, and within that Department there is also an impressive scientific and technological capacity to deal with programs. Nonetheless, the lesson accumulated, as leadership has succeeded leadership within the Department, is that even highly competent and highly analytical offices in the Office of the Secretary of Defense may at times be constrained in their judgments on many technicomilitary questions. Each regime has often analyzed the programs of its predecessors, disposing of some and advancing others for which, at times, it develops a special attachment.

It is unquestionable that the Secretary of Defense should be to the greatest extent possible master in his own house. Yet the normal processes of government dictate the presence of checks and balances

within the system. Fiscal constraints and program review, whether provided by the Office of Management and Budget or the Congress, constitute one such check. Other checks, including policy oversight, can be provided by the National Security Council and its staff.

But none of these sources of countervailing views has in the past or is in the future likely to have both sufficient scientific and technical capability and independence to provide a technically valid critique of defense policies or programs. Within the Office of Management and Budget, with its obligation to deal year to year within the sharp constraints of fiscal responsibilities, decisions concerning military research and development programs are likely to be based on short-term financial considerations. Because of the pressure of time, there is danger that these decisions may be excessively arbitrary.

Within the White House and directly under the President, general responsibility for national security policy is lodged with the National Security Council. Other agencies of the government can provide views on national security policies alternative to those of the Department of Defense, among them the Department of State, the Arms Control and Disarmament Agency, and the Central Intelligence Agency. The National Security Council possesses an apparatus designed to assess those various positions, analyze and compare them, provide alternatives of its own devising, and make recommendations to the President. The National Security Council does not itself possess competence in scientific and technological matters to the degree required for independent assessments of the implications of scientific and technological developments for national security policies. Since the demise of the White House science advisory mechanism, it has, however, found it necessary to utilize *ad hoc* arrangements for obtaining outside scientific and technical advice on specific problems.

It can be argued that the recourse is to endow the staffs of both the National Security Council and the Office of Management and Budget with substantial scientific and technical competence of their own. Indeed, it appears that there are cogent arguments for such a step, and the matter will be treated elsewhere in this report. The dialogue between the Council for Science and Technology and

National Security Council would be greatly enhanced if adequate scientific and technical competence were to exist on the National Security Council staff; that is implicit in the very notion of dialogue. In the present context, however, it is our view that, at the level of major policy and management decision, even a strengthened in-house scientific capacity in these offices is unlikely to be sufficient.

But the insufficiency goes a step further. The Council for Science and Technology that we recommend and the manner in which we propose that it operate are designed to constitute a means by which thorough analyses and judgments of highly qualified, independent members of the scientific, technological, and engineering communities can be brought to bear on national security policies and programs. It is difficult to envisage an equivalent, fully developed capacity in either the National Security Council or the Office of Management and Budget.

Given the willingness of the President and his principal national security advisers to seek alternative options and hear alternative technical evaluations, the national security structure in the White House needs a way to obtain alternative views, soundly based technically, in evaluating present policies and determining future policies, in considering expensive weapons systems with strong even if unseen policy implications, and in being alert to new technological developments that might alter the national security picture. This cannot be done without a strong presence, within the Executive Office, possessing in its own terms a highly authoritative technical orientation, precisely the council that we propose here.

It is of material importance to point out that during the period when high-level, independent scientific and technological counsel was available to the President and to the apparatus of the National Security Council, impressive accomplishments were recorded in the areas under discussion in this section. Over most of its history, the President's Science Advisory Committee concentrated on matters of national security. A major study initiated in 1958 evaluated the technical feasibility of monitoring a ban on nuclear weapons tests, and its conclusions strengthened the hand of the President in continuing the test ban negotiations and deciding what to do. Another President's Science Advisory Committee panel formulated a series of recommendations that accelerated the early

development of the intercontinental ballistic missile capability. Another panel recommended to the President what turned out to be the design of a highly successful program for intelligence satellites. More recent studies have led to changes in national policy with respect to biological warfare, the stepped up deployment of the laser-guided bomb in Vietnam, and important contributions to submarine design. In another important direction, it was in large part through the efforts of the Science Adviser and the President's Science Advisory Committee that the high-level office of Director of Defense Research and Engineering was created within the Department of Defense.

There is a special need and opportunity for the proposed Council for Science and Technology to make a contribution to U.S. policy-making for arms limitation by ensuring that the judgments of scientists, engineers, and technologists are fully available in the process of analyzing various policy alternatives.

We have recommended that some formal association be created between the proposed Council for Science and Technology and the National Security Council. It may or may not be appropriate that the chairman of the Council for Science and Technology be a member of the National Security Council. We do believe that he should be invited to attend most meetings of the National Security Council and that, where appropriate, the Science and Technology Council staff be invited to participate in National Security Council studies. It might also be useful if there were at least one staff member with joint assignment to both the proposed Council and the National Security Council staffs.

Thus, to the extent that the work of the National Security Council is affected by considerations that arise out of science, technology, and engineering, the Council for Science and Technology can provide counsel and analysis related to early warning and to crisis management and, by doing so, can contribute in its own fashion to the formulation of national security policy alternatives from which policy itself will ultimately be chosen.

Role in Foreign Policy

5. We recommend a role for the Council for Science and Technology in those areas of foreign policy strongly affected by scientific and technological considerations.

A preceding section considered those aspects of policy that are inherently international, such as arms control and disarmament, or that are strongly affected by international considerations, such as national security. Yet for the United States, very little that concerns the government is totally lacking in international significance.

A scientific or technological development, whatever its direct effect on this nation may be, will often have effects upon other nations that can deeply affect in turn the relationships among nations and thus alter in some significant way the international scene. The inability of the Indian subcontinent to feed its people (and hence a portion of the political and international instability in that part of the world) can be attributed in some degree to scientific and technological advances in the control of disease that took place decades ago in continents away from India. Future scarcity of key raw materials and possibilities for substitution, both affected by developments in science and technology, have profound implications for the prospective relationships of the United States with both developed and developing nations.

Some specific issues that include strong scientific and technological components can readily be stated:

1. The United States is pursuing the development of a nuclear power industry for its own national purposes, and the scientific, technological, and engineering basis for such an industry is rapidly being produced. But the very success of that process will present international issues associated with the production of enriched fuel, the international availability of the technology, the security of fissionable materials, safety, and the disposal of wastes. None of these can be viewed as purely national issues; some, such as the security of fissionable materials and the safety of nuclear reactors, have international aspects of supreme importance.

2. Economically attractive applications of space technology will become more relevant with the passage of time and will require international policies and international machinery for operation and

control that far outrun existing experience. Earth resource satellites in particular raise important questions of control of information, international management, and national economic advantage. Policies in that area, as well as in navigation and broadcasting, will have to move substantially from present positions.

3. Regardless of the outcome of current negotiations on the law of the sea, the continued development of the deep ocean and the continental shelf will require constant review of those increasingly sensitive policies, with all their economic and political consequences.

4. The time is rapidly passing when environmental questions can be dealt with solely on a national basis. As the scale of activities grows and better information becomes available as to the real threats to the global environment, purely national solutions become increasingly inadequate. The policy problem is additionally intricate so long as nations in differing stages of development assign differing values to the maintenance of the integrity of the environment.

5. International trade questions are likely to become increasingly difficult, as well as increasingly important in economic and political terms, as issues arise associated with the sharing of technology, the transfer of technology through multinational corporations outside government control, the return on public investment in research and development, the control of information, the appearance and perhaps the maintenance of "technological gaps," and related questions. Among these are already highly controversial issues; each new technological advance adds to their importance.

These are the kinds of problems no nation can deal with effectively on a purely national basis. Yet unless they are clearly perceived in their international aspects, they will not be solved at all, or will be solved nationally or by means of cooperation among a few favored nations in a fashion that may serve to disturb further already unsatisfactory portions of our international posture.

In addition to these policy aspects of the interaction between science, technology, and engineering, on the one hand, and foreign policy, on the other, there are other aspects with a long history of their own. There has been over the years a variety of technical assistance programs intended to make available in some degree the technological resources of this country to assist the development of countries that possess little or no such capacity of their own. The

plight of developing nations, especially after the oil price rise, is likely to result in increased attention to the possibility of applying U.S. scientific and technological resources to the alleviation of their problems, particularly food and population.

The existing policy process for international aspects of programs in which science and technology are closely involved is complex. Each agency and department has its own international program and has a major role in policies that affect it. The Bureau of International Scientific and Technological Affairs in the Department of State attempts to coordinate policy and to guide agencies on important issues, but has severe problems of information and influence. Under the circumstances, it performs its tasks admirably. But only the most significant issues receive top-level attention either within the Department or at the level of the White House, and many of the subjects relevant to science and technology receive little leadership or effective guidance until they reach crisis proportions or cause major political problems.

It is the view of this committee that a strong coupling between the Council for Science and Technology and the Department of State, in close consultation with the National Security Council, would enable the Department to perform its own functions in a manner that it will find to be progressively more satisfactory. As we have stated with reference to domestic departments, there is every reason to believe that coupling can be achieved without threat, or the perception of threat, to the integrity of the Department itself.

That coupling would enable the council to provide in international matters the early warning and coordinated attention to crisis management and selective program development that have been suggested here as among the principal functions of the council. It would enable the council to intervene, side by side with those within the Department of State responsible for scientific affairs, at the points where policy is actively determined, particularly where Presidential initiatives or interests are immediately involved.

We make no specific recommendation as to the exact manner in which the coupling might be achieved. We believe this is a matter to be worked out between the Department and the council, with complete deference to the integrity of each of the institutions involved.

Relationship to the Office of Management and Budget

6. *We recommend that the Council for Science and Technology cooperate closely with the Office of Management and Budget on significant budget and management issues involving science and technology.*

The Office of Management and Budget (OMB) is responsible, by Reorganization Plan No. 2 of 1970, for assistance to the President in the preparation of the annual budget and the oversight of its execution. More specifically, the OMB is to provide fiscal analysis, the evaluation and coordination of programs as they are brought forward, and the continuing assessment of the extent to which programs are achieving their intended results.

To fulfill those responsibilities, the OMB is bound by the calendar of the fiscal year. OMB puts together the budget proposal that the President must deliver to the Congress each January. However, the moment at which the budget is delivered is not a moment of surcease for OMB. While Congress deals with the budget proposal that has been laid before it, the OMB must begin to address the next budget, governing a fiscal year whose commencement lies eighteen months away. At this time, the major program issues in the next budget are examined and the agency must give guidance to all departments and agencies so as to prepare them for major budget questions that are likely to emerge in the course of the Director's fall budget review.

The process is endless, and it is carried out under a harrying pressure of time. The target figure for expenditures is established on the basis of economic and political considerations; OMB must struggle to make the needs of the system fit that figure. Those seemingly irreconcilable demands and the time pressure under which they must be satisfied set the tone of the OMB. It is not the easiest of tasks.

Decisions must be made within OMB concerning budget items dealing directly with activities within those fields included in the budget submissions of the departments and agencies. Collectively, the budget proposals, including activities in science and technology, inevitably are larger than the resources available to the govern-

ment will permit, and each agency proposal must be constrained to fit the budget as a whole in terms of need, effectiveness, and immediacy. The research and development budget, scattered among all the government agencies, amounts in fiscal 1975 to about 20 billion as submitted to the Congress.

To accomplish its mission, OMB is organized according to major functional areas, each under an associate director. All departments and agencies dealing, for example, with national security and international affairs fall into one such area; those dealing with "human affairs" under another. Natural resources, energy, and science are grouped under another associate director.

The efficiency of such an arrangement is obvious, but it promotes corners of inefficiency. Programs for the support of research and development are found in the budgets of numerous departments and agencies reporting to OMB and, thus, are handled in each of the OMB functional areas independently. Such a system, strictly pursued, would not entail any global examination of those scientific and technological activities as a whole; they would be examined only as small parts of a whole. Accordingly, OMB seeks also to look at selected scientific and technical programs that cut across its own functional structure.

It is clear that scientific and technological competence must be brought to bear upon those aspects of the work of OMB that involve science, technology, and engineering. As in all such instances, that competence can be provided within the organization, or on an advisory basis can be provided from outside. At present this competence is marshaled largely from within the OMB professional staff, which includes a small number trained in science and engineering.

In the past, much of the required counsel was provided by the President's Science Adviser and the Office of Science and Technology (OST). The Science Adviser attended budget review meetings of the Bureau of the Budget (later the OMB); the staff of the Office of Science and Technology enjoyed day-to-day association with the staff of OMB; panels of the President's Science Advisory Committee were called into being to conduct program review and evaluation and provide those services through the Science Adviser and OST, as part of a broader assignment. The dissolution of OST has placed a portion of this practice out of reach, and re-creation

of an OST-type organization within OMB would in time merely create what we regard as the inadequacies of an inhouse system.

The assimilation of the title of President's Science Adviser with that of Director of the National Science Foundation presents a somewhat different set of problems in relation to the budget process. It is not merely that an Adviser outside the White House and the Executive Office has a different status than one who is within it. It is also the untenable position of one who is at the same time both applicant to the OMB and counselor to it, who must at the same time battle for the prerogatives of science and technology and weigh those prerogatives against the demands of others who make competing claims on resources. Because of his concern for the manifest conflict of interest, he does not attend budget review meetings, although his effectiveness as Science Adviser may depend on his doing so. He has assigned that responsibility to a senior member of his staff, and it is diligently carried out, but in practice the conflict of interest remains at any level within the Foundation. The effect, whatever the table of organization might suggest, is to prevent the kind of relationship with the programs review and budgeting mechanism that was once enjoyed by the President's Science Adviser and by the OST and President's Science Advisory Committee panel system over which he presided.

We urge that the Office of Management and Budget augment and maintain its own technical capability to perform the tasks that are set for it. The Council for Science and Technology would become an important and in time an irreplaceable resource for OMB, serving that office as it would serve other agencies of the Executive Office and the White House. In particular, the creation of the council would restore an important capability for critically appraising proposals for weapons, space, and intelligence systems involving sophisticated technology, as it would contribute to the resolution of scientific and technical issues in programs for dealing with societal problems.

As part of its ordinary operations, OMB must deal with matters that affect the scientific and technical enterprises themselves. It must pass upon the budget requests of the National Science Foundation and the National Institutes of Health, as it must on the scientific research programs of all other departments and agencies. Thus, OMB activities have direct consequences for scientific and

technical manpower, for the health of educational and other nonprofit institutions that are so essential a part of the total scientific and technical effort, and for the maintenance of a powerful, balanced scientific base.

The council can only be expected to be effective in serving the President if it is actively aware of the strengths, deficits, and opportunities of the overall national scientific endeavor. The federal government is the major sponsor of that endeavor, but does so through the aggregated programs of virtually all federal agencies. Furthermore, we believe that the council, if it succeeds in the main tasks we assign to the degree that we hope it will, will inevitably play the role for which it is best suited in the area of science policy, simply because it will be naturally looked to for that role and would be qualified to play it.

Annual Reports

7. *We recommend that the Council for Science and Technology submit an annual report to the President, and through him to the Congress, on major developments in science and technology of significance for national policy.*

We have sought to make it clear throughout this report that the primary responsibility of the Council for Science and Technology, like that of all institutions and individuals within the Executive Office, is to the President. There must be occasions when that responsibility is exercised directly, and others when it is exercised through other elements in the President's household. But the products of the council's deliberations, whether they have been created in response to the expressed needs of the Executive or upon the initiative of the council itself, exist to serve the President and stand at his disposition.

On the other hand, there is great value in the preparation of an annual report consciously intended for wider dissemination. Such a reporting procedure already exists for the Council of Economic Advisers, under the legislation that created that council. It has proved most useful to the Congress and to the general public, as well as to the President.

The purpose of such a report must be carefully defined. It appears to us that it should deal primarily with trends and developments within science and technology that have national significance in that they offer new opportunities or raise important problems. Some of those opportunities and problems will be within science and technology themselves and will raise issues of science policy. But for the Congress and for the public-at-large, the most important service the report can provide will be to illuminate opportunities and problems that affect the society as a whole.

It will not, however, be the purpose of the report to draw conclusions concerning the resources that should be allocated in order to exploit the opportunities, or on the decisions that should be taken in order to meet the problems. Those conclusions can never be the consequence of scientific and technological considerations alone, although they may be deeply affected by those considerations and can never safely ignore them. Science and technology are often capable of exposing societal issues that have arisen from their efforts; they are not often capable of resolving those issues, which usually possess significant and perhaps overwhelming components that relate beyond the science and technology to social, institutional, moral, and political questions.

That very fact, however, underlines the utility of an early and an authoritative exposure of the issues themselves. Ultimately, their resolution will be the consequence of the actions of the Congress and of the institutions, private and public, that society has created. In a democracy, they can never be satisfactorily resolved unless the public-at-large has some clear notions of the underlying realities, and in any matter of significance it is never too early to begin providing those notions.

CHAPTER THREE

CONCLUDING OBSERVATIONS

In the preparation of this report we have been conscious that a majority of the committee is drawn from among persons with direct or indirect engagement in science, technology, and engineering. We all agree with the general proposition that these are human undertakings of enormous scope and beauty and a source of intense intellectual satisfaction. We see them all as activities spread along a spectrum of certain kinds of intellectual and aesthetic enterprises warranting support in their own right. In this report we have taken a largely utilitarian view of those enterprises, but we do not think it the sole view. Hence, we both hope and believe that, in serving the needs of the President, a Council for Science and Technology will inevitably be concerned with all aspects of the scientific undertaking and, consequently, with the general health of the scientific and technological activities of the nation, whether governmental or private.

We believe, too, that many scientists and engineers are, in their own right, highly qualified to serve in the domain of politics and policymaking. Because the paths of their careers do not customarily lead them early into the areas of politics or general policymaking, they do not often make their way up the rungs of political advancement and find themselves in the high councils of govern-

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ment as a matter of normal career progress. Yet they may have the same talents as those who do, and it is in the best interests of government as well as science and technology that those talents be utilized.

Finally, this committee believes that the considerations that led to its formation are of great importance to American society. Whatever objection may be directed from time to time at certain aspects of science, technology, and subsequent engineering, the human disposition will not let them vanish. There is no means of returning to a pretechnological past, in part because it is a past that is inexpressibly remote if it ever existed at all among creatures we would recognize as human, in part because there is no real urge to do so. We live in a century of science and technology, driven by man's situation and his aspirations, and we are moving toward a future of more science and more technology. What we have sought to promote in this report is one means, among many means that will be necessary, to make science, technology, and engineering more responsive to human needs.

ACKNOWLEDGMENTS

In the course of its work, the committee profited from the views of a number of highly qualified persons within and outside the federal government with special vantage points and experience concerning government decision making involving science and technology.

Drs. Killian and Rice met with highly placed officials in the White House and Executive Office of the President and in the Congress.

The committee invited the following people to appear at its meetings in order to gain first-hand understanding of the current arrangements for providing scientific and technological counsel to the Office of the President: H. Guyford Stever, Science Adviser to the President and Director of the National Science Foundation; Hugh Loweth, Deputy Associate Director of the Office of Management and Budget; Philip Smith, formerly of the OMB staff; Glenn Schleede, a senior staff member of the Domestic Council; and Alvin M. Weinberg, Federal Energy Office.

Others who counseled with the committee during its meetings were Pierre Aigrain, former principal science and technology adviser to the French government; Harvey Brooks, Harvard Uni-

versity; Alton Frye, Council on Foreign Relations; Don K. Price, Harvard University; Jerome B. Wiesner and David C. White, Massachusetts Institute of Technology. Robert N. Kreidler of the Alfred P. Sloan Foundation on our invitation found it possible to attend all the meetings of the committee.

The committee is most grateful for the advice of former Presidential Science Advisers: Jerome B. Wiesner; Donald F. Hornig, Brown University; Lee A. DuBridge, Laguna Hills, California; and Edward E. David, Gould Industries. Dr. George B. Kistiakowsky, Harvard University, kindly made available the manuscript of his article, "Presidential Science Advising," which was subsequently published in *Science*.

A special note of appreciation is accorded Stephen White of the Alfred P. Sloan Foundation, who shouldered a major part of the drafting of our report.

The committee wishes to acknowledge the invaluable assistance of an able and dedicated staff: David Beckler, Executive Assistant to the committee, and Rose Kaufman, Administrative Assistant, both of the National Academy of Sciences.

The committee is deeply indebted to the following people, who prepared background papers to illuminate the decision-making process in a number of selected problem areas of national concern having substantial scientific and technological content:

SUBJECT	BRIEF HIGHLIGHT	CONTRIBUTOR
Food and agriculture	Identifies science and technology issues in national land and water policy, agriculture and forestry policy, and food and nutrition policy	Theodore Byerly Agricultural Consultant
Nonrenewable natural resources	There is need for a comprehensive national minerals policy embracing national needs for minerals, the environmental consequences of their production and use, and international aspects of trade and diplomacy	Preston Cloud University of California Elburt Osborn U.S. Bureau of Mines
Energy	Calls for a guiding set of principles for use in future energy decisions that relate scientific and technological considerations to the resource, environmental, economic and political factors	David White Massachusetts Institute of Technology

SUBJECT	BRIEF HIGHLIGHT	CONTRIBUTOR
Health services	The policy process needs input at the highest level from those who are concerned with the development of new knowledge about the delivery of health services in order to balance the pressures for immediate results with an understanding of the emergent nature of research in this field	Karl Yordy Institute of Medicine
Urban development	Newly available data, new computer technology and emerging knowledge of social class and life style suggest that research can provide a basis for making national policy and evaluating progress toward meeting housing needs	Bernard Frieden Massachusetts Institute of Technology
Basic science and graduate education	Discusses policy issues that need to be addressed in basic science and graduate education in science and technology and the lack of a capability or mechanism for policy setting	David Robinson Carnegie Corporation
Outer space	Points out how independent scientific and technical review outside of NASA has served to clarify issues in planning the space program and has contributed to more responsible judgments	Herbert Friedman Naval Research Laboratory
Federal policy for science and technology	The more effective application of the country's technical resources requires an institutional mechanism for formulating the technological component of economic and social policy that is not only technically competent but also effectively integrated into economic policy development	Lewis Branscomb IBM Corporation
National technology policy	Discusses the role of the federal government in promoting research and technological innovation in the civilian sector and the need for and organizational requirements of an effective federal technology policy	Richard Nelson Yale University

SUBJECT	BRIEF HIGHLIGHT	CONTRIBUTOR
Science, technology, and international affairs	Mentions a number of emerging international issues involving science and technology that must be faced by the government. Notes that only the most immediately significant, short-term issues receive top level attention but that the seeds of major problems, often raised by science and technology, can be dealt with more effectively through alternative mechanisms and attitudes.	Eugene Skolnikoff Massachusetts Institute of Technology
Transfer of government-financed technology to the public sector	Recognizes that the federal government is not the primary customer for a growing fraction of the research and development budget, and points to the need to modify existing federal institutions and policies to make them more effective in transferring the results of federal research and development to the marketplace	Raymond Bisplinghoff National Science Foundation
Scientific and technical advice to the Congress	Congress is becoming more sophisticated as regards science and technology, and there remains an urgent need for the Congress to obtain more sustained and more systematic technical assistance through a variety of resources within and without the legislative branch.	Alton Frye Council on Foreign Relations
Decisions at a higher order of abstraction	By improved understanding of how a person makes a decision based in large part on information which he can understand only indirectly, it should be possible to increase the effectiveness of comunications between scientific and technical persons and policymakers.	Raymond Bauer Harvard University
Early warning for policymakers	In order to better integrate science and technology advice into political and social thinking about the future, there is need for "interpreters" who can translate such advice in terms that the politician and decision maker would consider most relevant to his perspectives and to the issues as he is likely to perceive them in light of the facts presented.	Harvey Brooks Harvard University